DOCUMENT RESUME

ED 268 125 TM 850 387

AUTHOR Allison, Dennis J.
TITLE An Array Processing Theory of Memory, Thought, and Behavior Patterning: A Radically Reconstructive View.
PUB DATE 84
NOTE 16p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Artificial Intelligence; *Cognitive Processes; Computers; Computer Science; Information Processing; Learning Processes; *Learning Theories; *Memory; Metaphors; Models; Neurological Organization; *Schemata (Cognition)
IDENTIFIERS *Array Transformation

ABSTRACT

A theory of memory is introduced, which seeks to respond to the shortcomings of existing theories based on metaphors. Memory is presented as a mechanism, a comparison process in which information held in some form of immediate storage (whether based on perception or previous cognition or both) is compared to previously stored long-term storage. Human memory is compared to filing systems, semantic organization, and computers. The proposed theory suggests that no memory, thought, or behavioral pattern is stored as a discrete entity, but exists only within a compendium of molecular fragments of basic schemata which are assembled, through a process of array association. According to this model, memories and concepts are generated through a dynamic process when they are needed. It is assumed that information remains in an array format and that it is always in neuronal form. The complex process of array association describes memories as being elicited from the interaction of an input array and a master memory array, resulting in a third product array. The master memory array is assumed to be the brain's cerebral cortex; other portions of the brain are relevant to memory only insofar as they facilitate or inhibit the cortex's basic processes. (GDC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED268125

An Array Processing Theory of Memory, Thought, and Behavior Patterning:

A Radically Reconstructive View

Dennis J. Allison

Baylor University

Olin E. Teague Veterans Medical Center

Running head: An Array Theory of Memory, Thought, and Behavior

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Allison, Dennis J.

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

TM 850 387

BEST COPY AVAILABLE

Abstract

This paper introduces a theory of memory, more closely modeled upon present knowledge of neurological rather than computer structure and function, which is based upon a central mechanism of array transformation. A brief description of the mechanism is given. The relationship of the theory is explored to several current problems in memory theory, including emotion, computer analogies, and the knowledge base problem of artificial intelligence. Problems in the theory are explored, including the need for empirical validation.

BEST COPY AVAILABLE

An Array Processing Theory of Memory, Thought, and Behavior Patterning:

A Radically Reconstructive View

This paper might also be subtitled "from metaphor to mechanism," because the idea underlying this paper began with a previous evaluation (Allison, 1983) of the metaphors underlying present theories of memory. A mechanism is presented here to respond to shortcomings of existing theories which are seen to follow from premises rooted in these metaphors.

At an irreducible minimum, memory is here considered to be a comparison process in which information that we are holding in some form of immediate storage--whether it is primarily perceptually based, primarily the result of previous cognitive processes (including previous memory), or both--is compared to some information which we have somehow previously stored in a higher capacity long-term storage.

The Premise of Discreet Comparison

If we consider analogous situations of how humans store information in the external world, we find that typically some discreet physical representation is made--usually on a piece of paper or a tape-like continous medium--and stored in a discreet physical place under some type of filing system. Computers follow this same proceedure with electronically coded material, even using the term "file" for the discreet copy and the term "address" for the specific location of the information in the system.

Filing systems commonly have many problems, including those of space, search, time, and judgement or decision making. To use any filing system, we must first decide what to look for,

BEST COPY AVAILABLE

then decide how to search for it. To ask who is doing this decision making is to raise the problem of the homunculus, a somewhat obscured but very real problem existing in all filing systems. (This problem also exists for computers; the programmer is the computer's homunculus.)

To ask how to search leads to the need to decide on an organizational principle for a search. For example, one might upon a simple exhaustive item-by-item comparison (very time consuming) or some method of categorical search (more efficient but requiring complex decision making). Space is a familiar problem to anyone who has attempted to maintain all but the smallest filing systems. The problem of finding the time to look through a complex set of files will also be familiar, as well as the problem af taking the time to devise and organize as effective system of categorization of files.

To translate the problem back to human memory, several observations are made. First, human memory processes occur in an incredibly small space, within the human skull. Second, the search time is often incredibly fast, given the vast amount of information to which we have access. Third, we are often unaware of the organizational principle behind the search, memories often coming to us through obscure and unplanned associations. No clear model of the organizational structure of human memory has yet been possible (Hunt, 1982). Fourth, discreet filing systems require a person making judgements who is external to the system, and thus introduce the homunculus. Due to such considerations, the premise of discreet comparisons is rejected as lacking parsimony.

Semantic Networks and Computers

Semantic network theories are here considered to be a particular type of a discreet filing

BEST COPY AVAILABLE

system in which semantic information is filed using a semantic organizational principle for categorization. The serial decision making requirement of such theories considered to be a particularly problematic time constraint. Also, the category inclusion decisions involve high-level judgement, introducing the homunculus issue. Therefore, the notion of semantic network is also set aside.

It is interesting to note that the most ambitious efforts to replicate human memory processes with the mechanism of the computer, those of artificial intelligence research (McCorduck, 1979), have experienced precisely the problems of space, time, search method, and decision making. A general rubric for these problems, the "knowledge-base problem," directly involvies the problem of discreet comparisons. Ironically, this problem represents the difficulty that the mechanism of the computer has in making metaphorical comparisons.

Computers are by their nature, mechanisms for exact comparison. Metaphor is the process of inexact comparison, or looking for inexact similarity across classes. Computers can be made to deal only quite awkwardly with the relation of one thing being "like" another. Humans, on the other hand, have a unique capacity to quickly and effectively "pass through" all of their knowledge base looking for such comparisons. Thus, computers, as they are presently designed, are rejected as both a metaphor and a mechanism for memory. They embody in their structure the filing metaphor of exact comparisons. Their mechanism is incapable of metaphorical search.

Overview of the Proposed Mechanism

The mechanism propsed in this paper is specifically designed to deal with the metaphorical concept of "likeness." It was first conceived during an effort to model a semantic network theory

BEST COPY AVAILABLE

(Norman and Rumelhart, 1976) in a computer-like decision system. Such great difficulties were encountered in explaining routing and comparison processes that a radically different approach was evolved which is not dependent on semantic space or networks.

The idea of "schema," however, (the greek word for form) remains central, if highly modified from the semantic network view. Form exists in our perceived world. In this this theory form is assumed to be first mirrored and then modified or transformed within the brain through various steps of coding until the final transformation results in the expression of the form, or schema, of behavior. Form is considered to be reflected in schemata (plural of schema) which are imbedded in arrays, much as an object is embedded in the array of points (pixels) on a T. V. screen. The heart of this theory has to do with a new view of how these arrays are handled, and how their component schemata are stored for future use.

Previous theories of memory have, for the most part, suggested that some medium must exist within the central nervous system for the storage of discreet memories. Such a medium has been described as an ongoing recording of temporal episodes similar to a videotape machine (Penfield, 1969), or as a series of templates (Selfridge,1959) or schemata (Rumelhart, 1978) representing objects, concepts, or other information which can be filed following some proceedure and then retrieved when desired. Loftus (1980) critisizes the ideas of Penfield and others, and suggests that, at least in part, memory is a fallible process in which we reconstruct possible episodes of past experience and then decide if these reconstructions are, in fact, real.

The Molecularization of Memory

The present paper proposes a thoroughly reconstructive view not only of memory, but also of

BEST COPY AVAILABLE

thought and behavior as well. It suggests that no memory, thought, or behavioral pattern is stored as a discreet entity, but rather exists only within a compendium of molecular fragments of basic schemata which are assembled, something as an alphabet is assembled into words, through a process of array association described below.

This "molecularization" of the process of memory obviates the need for creating, transmitting, and transforming and storing multiple memory templates of specific episodes of our past or of our varied concepts when we are not using them. Instead, memories and concepts are generated through a dynamic process when they are needed. Thus, the process of array association substitutes for the laborious, time consuming, and difficult to explain filing and search processes required by other theories. The present theory suggests that while we do not have the stupenously large capacity for discreet detail which some propose, we do have a marvelously efficient, dynamic and flexible system for reconstructing possible memories and concepts and testing them for plausibility.

It is assumed for the purposes of this paper and elsewhere (Allison, 1983) that, as pertains to the human central nervous system, information is collected, transmitted, and processed in the form of array-like, orderly arrangements of neuronal impulses, and that all information remains in an array format. It is explicitly assumed that information is not recoded from an array to a linear stream of data (as in modern computers). It is further assumed that information is always in neuronal form, that is, that individual values of the array are associated with individual neurons, whether that information is associated in electrical, chemical, or physical manner to that particular neuronal location.

BEST COPY AVAILABLE

Information still must be dealt with in discreet operations at some level, even if not as individual memories or concepts. The molecorization process here described changes the focus to two levels, first the level of the pixel, and second, the level of the basic schemata. By breaking up an image into pixels of relative light and dark, discreet operations may be performed on individual points of information as has already been described in much perceptual research (Hubel and Weisel, 1968). Associations of pixels, in the form of lines, may be considered to identifiable entities, most easily identified as familiar shapes or schemata. Given a sufficient number of basic schemata any particular combination could be produced.

The Process of Array Association

This theory suggests that memories are elicited from the interaction of an input array and a "master memory array." The input array consists of either perceptual information or of a previously elicited memory. The master memory array consists of a point-by-point correspondent array which records over the life of the individual the relative frequency which that particular pixel has been stimulated, by either perceptual or memory arrays, after information has been schematically aligned or registered. Problems inherrent in this process are discussed elsewhere (Allison, 1983, 1984).

The interaction of the two arrays is seen as a highly complex process. However, two basic processes are seen as central. The first process involves the simple subtraction of the values of the corresponding input and memory pixel. This produces a third array, which we will refer to as a product array. Pixels with a relatively low value in the product array indicate a primitive type of recognition for that particular pixel. The second process involves the summation of the

BEST COPY AVAILABLE

individual pixel values for the entire product array. This results in a single scalar value which represents a rough measure of recognition between the input array and the master memory array. This scalar value could be utilized in making decisions on future manipulations of the product array. In other words, the destination of the product array could be decided by specific scalar threshholds, or the interaction of different scalar values. Thus, thought, the manipulation of images or ideas, may be seen as an internal process, not requiring an external homunculus explaination. The intensity of this value could also be associated to specific schemata within the array which are providing most of the associative recognition. Thus, degrees of association or likeness, a rudimentary metaphorical comparison, can be envisioned.

Schemata, Emotion, and Brain Structure

Manipulating the intensity of expression of these schemata in the product array could be a basic aspect of emotion. In fact, in this theory, emotion is considered to be equivalent to the intensity with which schemata are expressed. It can be noted than that intensity could be embodied in perceptual schemata, in product (or memory) schemata, or in behavioral pattern schemata. In other words, this indicates that emotion (intensity or the marked lack of intensity) could be embodied in perceptions, thoughts, or behaviors.

Now we turn to the relationship of memory to brain structrue and function. It is a suggestion of this paper that the cerebral cortex and the master memory array are one in the same. In other words, this paper asserts that all areas of the cerebral cortex have one primary function, that is the reception, transformation, and transmission of array coded information. In addition to the two basic association processes mentioned, it assumed that various feature detectors also

BEST COPY AVAILABLE

operate. These serve to transform the array data into a form which is recognizable to another portion of the cerebral cortex (master memory array) to which it is routed.

It is not essential to the processes of memory that a specific type of feature detector transformation occurs, because the individual pixels of the recieving part of the array will "remember" it in any case. Also, various primary reception arrays can be overlayed upon each other with relative impuny for the same reason. Likewise, the summative recognition/association value for the entire hybrid array can easily be calculated regardless of any particularly recognizable form (to us) which resides there. However, the significance of such hybrid arrays is not whether or not we can recognize the forms or schemata which are present, but whether or not the succeeding portions of the cerebral cortex (master memory array) to which the associative products are routed can make use of the schematic information thus embodied. Finally, this means whether of not the behavioral output portions of the cerebral cortex can generate ordered behavior as a final outcome.

In this model, portions of the brain other than the cerebral cortex are seen as relevant to the processes of memory only insofar as they facilitate or inhibit the basic processes described for the cortex. It is thout that this selective process of facilitation ant inhibition is the process which coordinates the interaction of memory and perception to produce coordinated thought and behavior. It is assumed that schemata are selectively intensified of dulled in their expression through the processing of scalar association values for entire arrays as well as schemata (individual portions of arrays). The limbic system and the hippocampal formation are obvious candidates for such a function. The basal ganglia may provide the basic behavioral schematic

BEST COPY AVAILABLE

"alphabet" which are ordered by cortical output. The cerebellum might be seen as providing a necessary "smoothing" to the discontinuous progression of sequential arrays. Electroencephalograms, or brain waves, might be a measure of the presence of these ongoing array movements.

Human and Computer Memory Differences

Modern computers are not designed to deal primarily with arrays. They can be programmed to process array information, but only by transforming it into a linear stream of data on which to perform individual operations. The array processing model posits a simultaneous and interdependent processing of all points or pixels of all arrays within the system. This puts even the most ambitious plans for parallel processing in future computers to shame (McCorduck, 1979). It also presents us with an unusually unpredictable and probably uncontrollable system. This might serve as a warning to those who might overzealously develop the hardware for this type of system. Such themes are hinted at in Von Neumans seminal work (1958).

Another element of the difference between the function of the human brain and that of the computer is the mode of comparison: The human is metaphoric; the computer is exact. We as humans, routinely compare items form broadly different classes, apples and oranges, so to speak. Through this metaphorical method we have extremely fast access to some logically remote parts of our experience. literature is an excercise in such thinking, of which computers seem incapable. Array processing guided by scalar values seems a natural mode for such metaphorical comparison. The overall association value between two arrays does not depend upon any one logical component, but may result from a number of quite small associations summed together. We might even sense

BEST COPY AVAILABLE

an association yet not be able to explain why we experience it. This is a type of "unconcious" association phenomenon. Feelings on the borderline of clear consciousness, such as intuition, suspicion, curiosity, and creativity might also be accounted for by a threshhold attainment of associative scalar values.

Relationship to Other Psychological Phenomena

Other psychological phenomena might be related to the array-processing model. Since input arrays are assumed to be necessary for the system to work properly, dreams and hallucinations might be the result of the system "freewheeling" without appropriate input controll. Classical conditioning might represent the ability of schema to be expressed when a separate schema in memory is elicited. Operant conditioning might represent the tendency to maximize the association between a behavioral pattern schema and an array image of a desired future state of affairs. Modeling within the social learning theory paradigm might be explained by the direct mapping of thr perception of someonelse performing a behavior onto our own behavioral pattern elicitation areas. Hypnotism might refer to the turning over of the control of our own scalar value processing system to another person.

To return to a narrower focus from such broad speculation, the general significance of this model to memory theory is that memory becomes, in this theory, the sum total of the potential products of the interaction between the input array and the master memory array. The potential products are just that, they are potential and not discreetly stored anywhere. We might say that the memories are stored insome sort of jumble of schemata on the master memory array. However, this is not precisely true, because the actual elicitation of a product array requires the addition

BEST COPY AVAILABLE

of organized schematic information from the input array.

In this model, long-term memory becomes the sum total of potential but as yet unelicited products of the interaction between the master memory and all possible input arrays. Difficulty in recalling items of information which we know but cannot remember at this particular time may be interpreted as simply not being able to find an effective input array to associate with the master memory array. Thus, finding the proper input array is analogous to the template search or file location problem of previous theories. However, scalar value processing is seen as guiding the selection process in array processing terms. (Other theories must still face the problem of what or who decides what to search for in the first place.) Short-term memory becomes, in this theory, the contents of actually elicited product arrays.

Discussion

It is clear that whenever someone proposes a different view of such a basic process as memory ther may be ramifications in many if not most areas of psychology. However, some major themes of the new theory should be emphasized. The first assertion is that memory is not stored as discreet episodic or conceptual units. The second assertion is that memory is always processed or stored--even when a jumbled or compressed format--in some form of neuronally based array. A third assertion is that perceptual and memory based input is processed in essentially the same way. A fourth assertion is that all areas of the cerebral cortex operate as a part of the master memory array, and function in essentially the same way. The final and most important assertion is that scalar values must be used to successfully replicate broadly metaphorical processes in the brain, and that an array association process is the most flexible and likely candidate to explain

BEST COPY AVAILABLE

those processes. Further, the use of array generated scalar values in controlling and guiding thought processes is seen a plausible approach to avoiding the need of introducing a source of external judgement, or the homunculus.

Problems with the herein presented include, first and foremost, the lack of experimentally testable hypotheses at present. A second problem is to explain the notion of the equipotentiality of portions of the same area of the brain, as discussed in detail by Lashley (1950). A third problem is to explain the problem of perceptual unities, or how incoming information is registered on the area of the appropriate schemata within the master memory array. (The last two problems seem related and may turn out to be part of the same problem).

Clearly, the present theory is in its infancy. Much thought and work remains to be done to even hint at its overall feasability. It is hoped that regardless of whether the theory turns out to be valid that it will stimulate new ways of envisioning memory and other mental processes.

BEST COPY AVAILABLE

References

Allison, D. J. (1983). Memory, thought, and play: Associations and operations in human experience. Unpublished manuscript.

Allison, D. J. (1984). An array processing theory of memory. Unpublished manuscript.

Lashley, K. D. (1950). In search of the engram. Symposium of the Society for Experimental Biology, 4, 454-482.

Hunt, M. (1982). The universe within. New York: Simon & Schuster.

Loftus, E. F. (1980). Memory: Surprising new insights into how we remember and why we forget. Reading, MA: Addison Wesley.

McCorduck, P. (1979). Machines who think. San Francisco: Freeman.

Norman, D. A., Rumelhart, D. E., & the LNR Research Group. (1975). Explorations in cognition. San Francisco: Freeman.

Penfield, W. (1969). Consciousness, memory and man's conditioned reflexes. In K. Pribram (Ed.). On the biology of learning (pp. 127-168). New York: Harcourt, Brace & World.

Rummelhart, D. E. (1978). Schemata: The building blocks of cognition. San Diego: University of California at San Diego, Center for Human Information Processing, CHIP Report No. 79.

Selfridge, O. (1959). Pandemonium: A paradigm for learning. In Symposium on the mechanization of thought processes. London: HM Stationery Office.

Von Neuman, J. (1958). The computer and the brain. New Haven, CT: Yale University Press.

BEST COPY AVAILABLE